

NEW RELATIVE HOLOCENE SEA-LEVEL CURVE FOR SAN FRANCISCO BAY, CALIFORNIA, USA

Jack Meyer
Far Western Research, Davis, CA

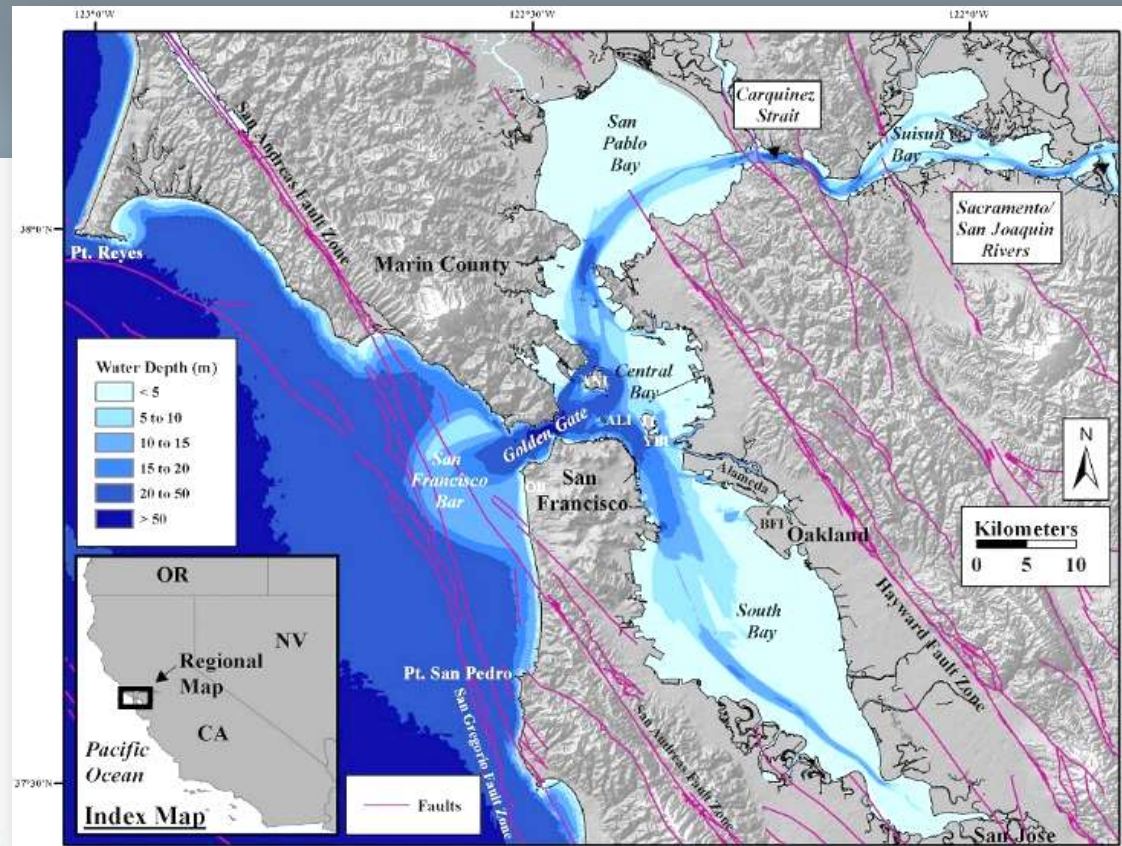
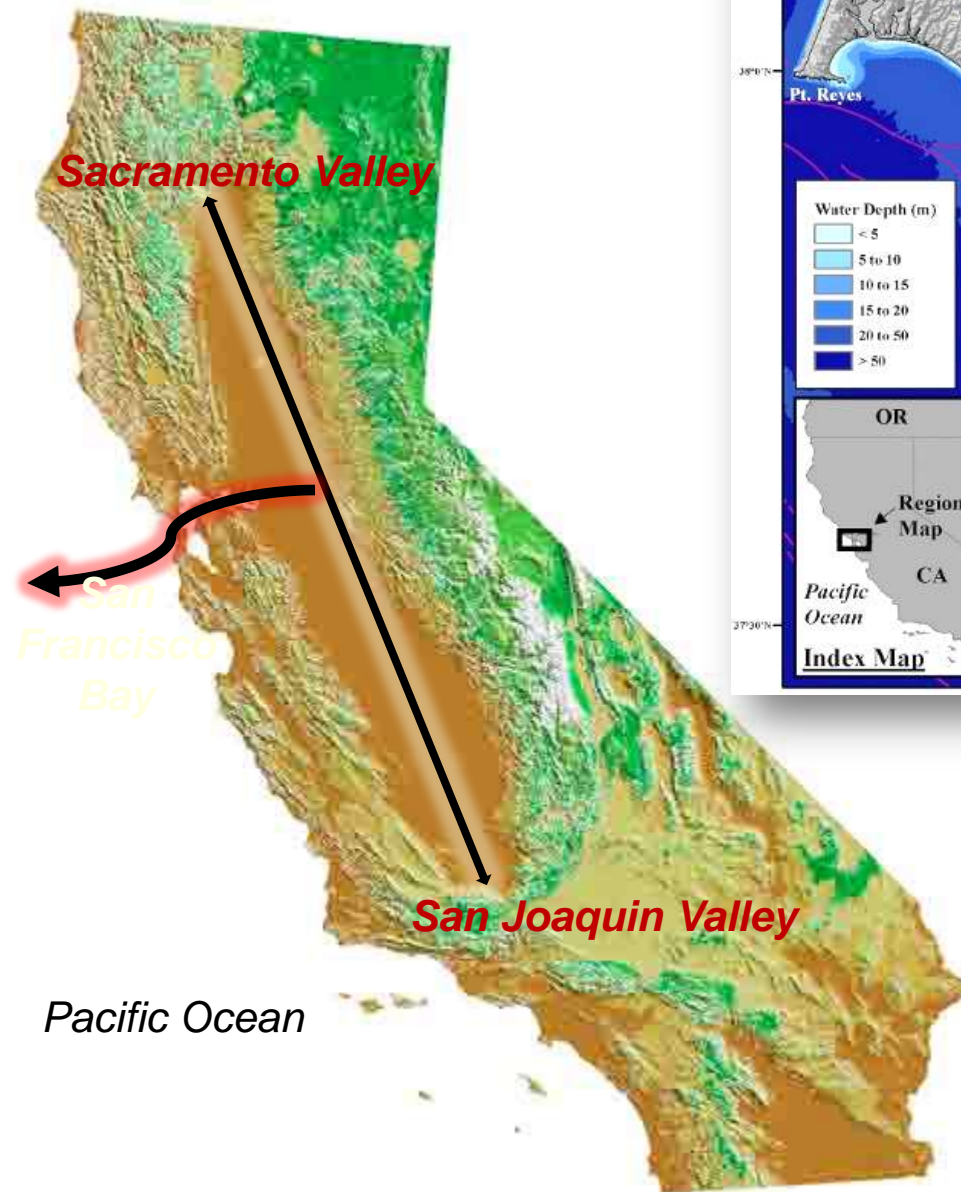


GSA 2014

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OF AMERICA

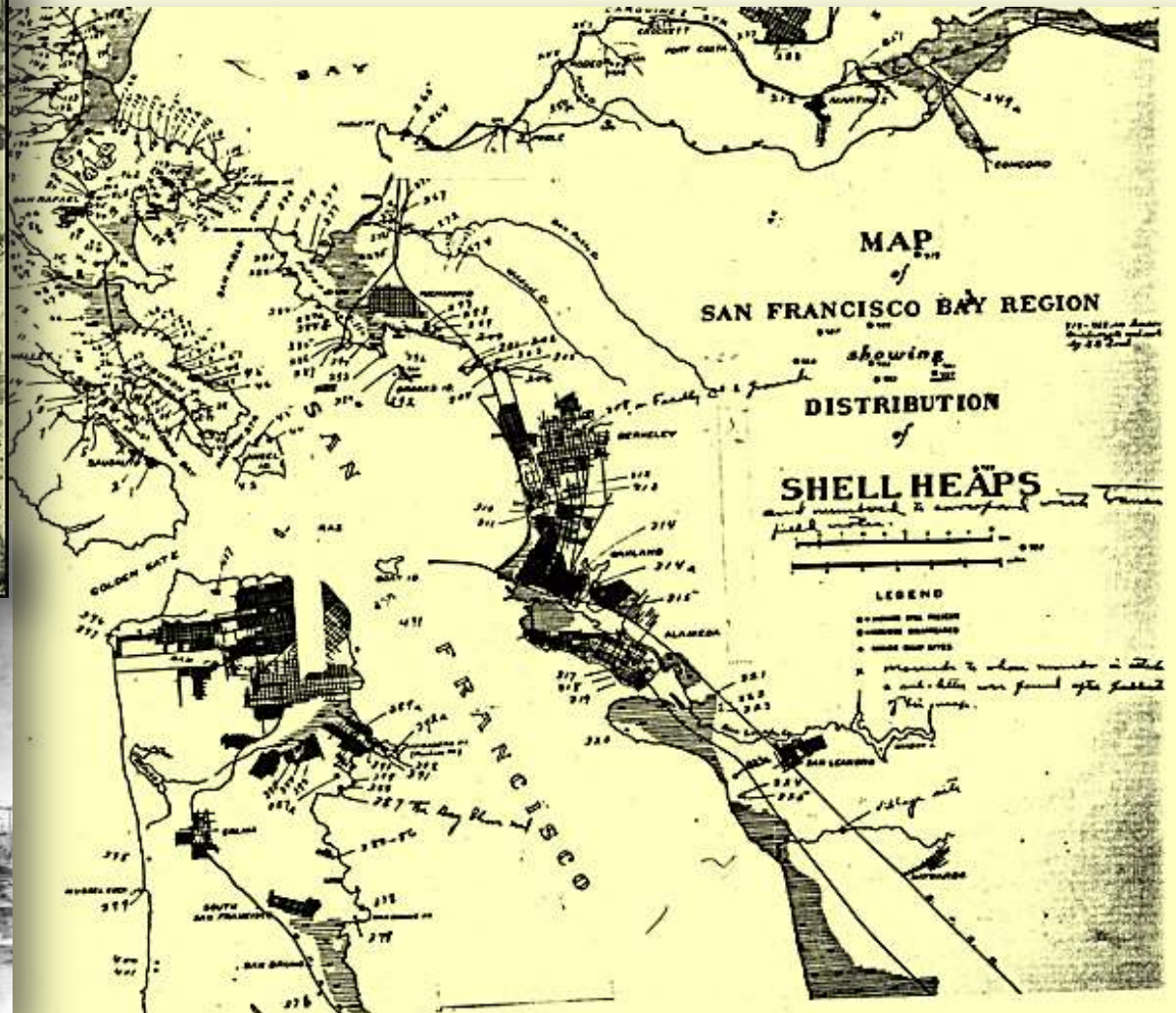


San Francisco Bay is:

- Largest Pacific estuary in Americas
- State's largest freshwater drainage outlet
- Carries 40% of State's runoff



The image consists of two black and white photographs of an archaeological excavation. The top photograph shows a deep, narrow trench with steep, eroded walls. A person is standing at the bottom of the trench, providing a sense of scale. In the background, a wooden structure, possibly a ladder or scaffolding, is visible against a hillside. The bottom photograph shows a similar trench, but with a person standing in the center. On the left wall, a large, rounded object, possibly a barrel or a large pot, is visible. The ground at the bottom of the trench is uneven and appears to be covered in dirt or debris.



Post-Glacial Sea-Level Rise

During the Last Glacial Maximum the sea was more than 100 meters (300 feet) lower than today.

By the time people were present in the region around 13,000 years ago, the sea was still more than 70 meters (230 feet) lower than present.



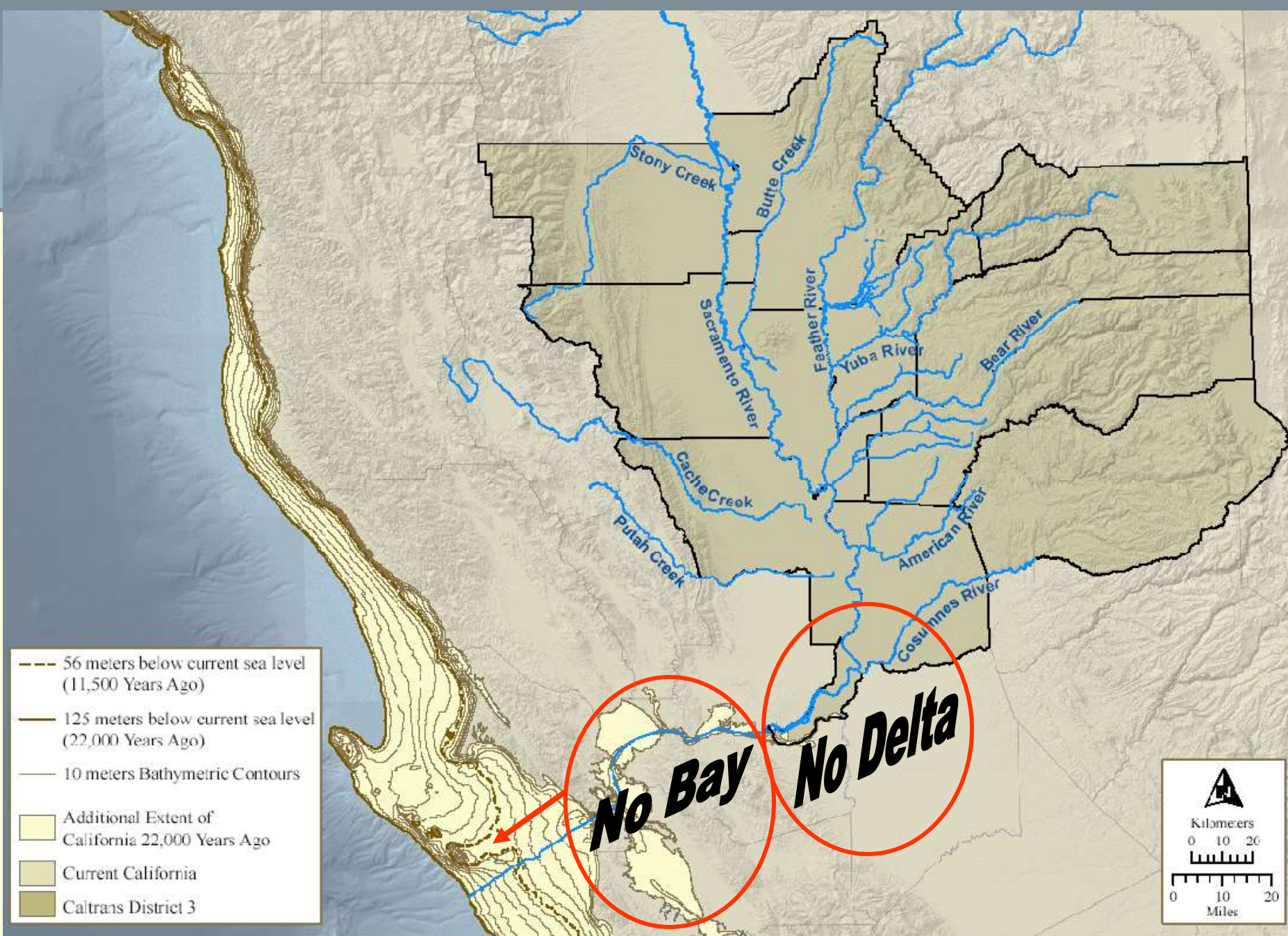


Figure 6. Maximum Extent of Sea-Level Lowering in Central California during the Last Major Glacial Period.

15,000 cal BP sea level

Sacramento

Sonoma

Napa

Concord

Golden Gate

San Francisco

Oakland

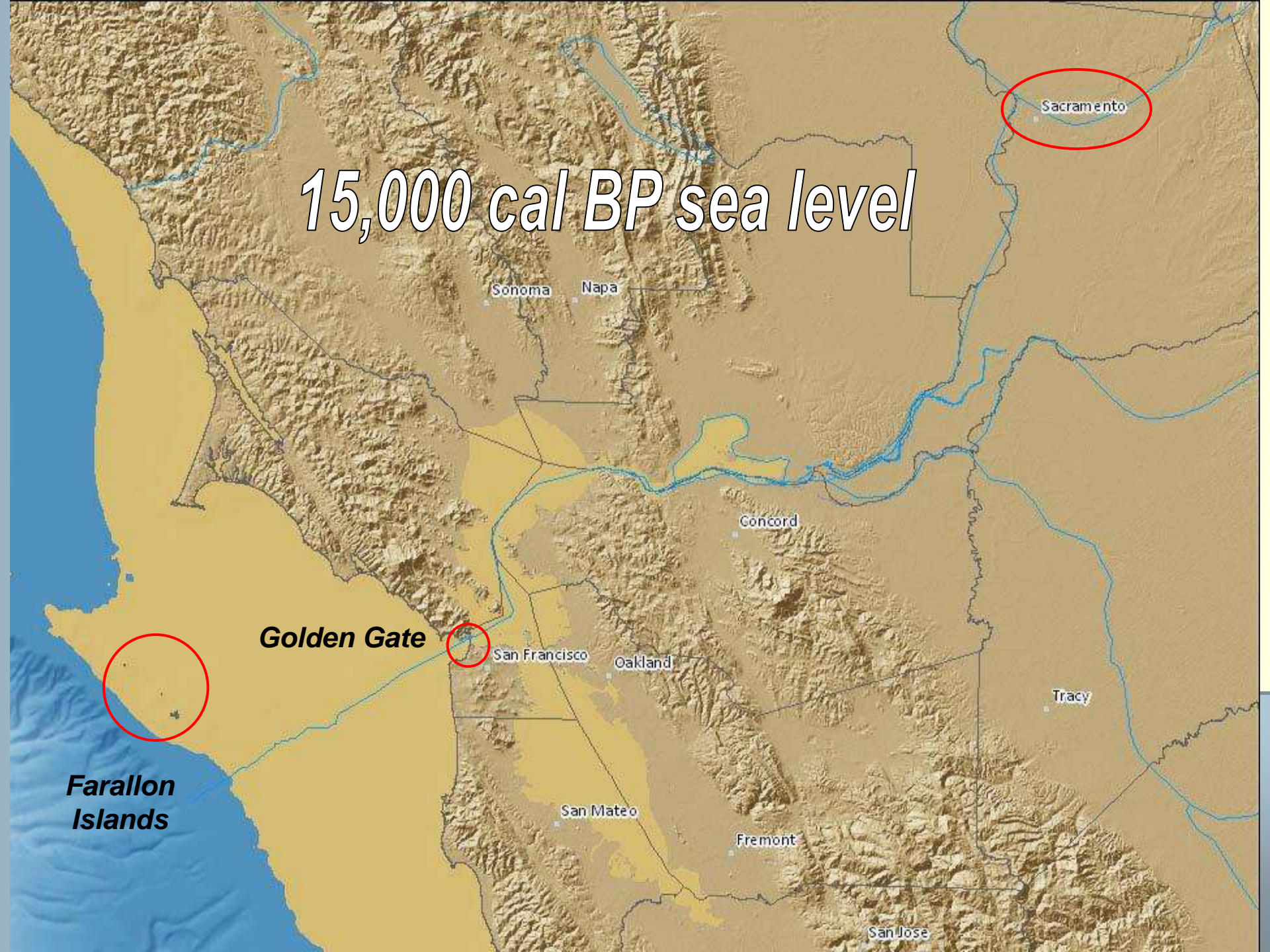
Tracy

San Mateo

Fremont

San Jose

**Farallon
Islands**



11,000 cal BP sea level

Sacramento

Sonoma

Napa

Concord

Golden Gate

San Francisco

Oakland

Tracy

San Mateo

Fremont

San Jose

**Farallon
Islands**



4000 cal BP sea level

Sacramento

Sonoma

Napa

Concord

Golden Gate

San Francisco

Oakland

Tracy

San Mateo

Fremont

San Jose

**Farallon
Islands**



Present sea level

Sonoma

Napa

Sacramento

Concord

Golden Gate

San Francisco

Oakland

Tracy

San Mateo

Fremont

San Jose

**Farallon
Islands**



Sea Level Entered the Lower Sacramento-San Joaquin Delta about 7000 years ago

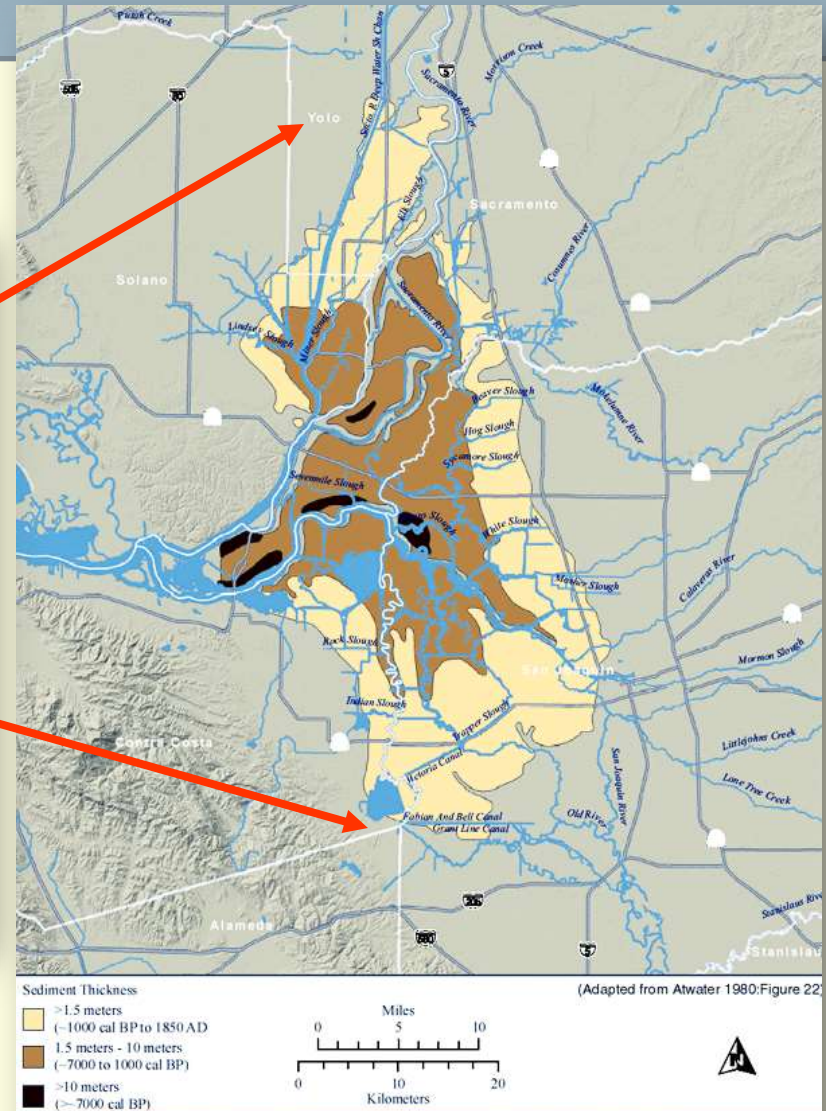
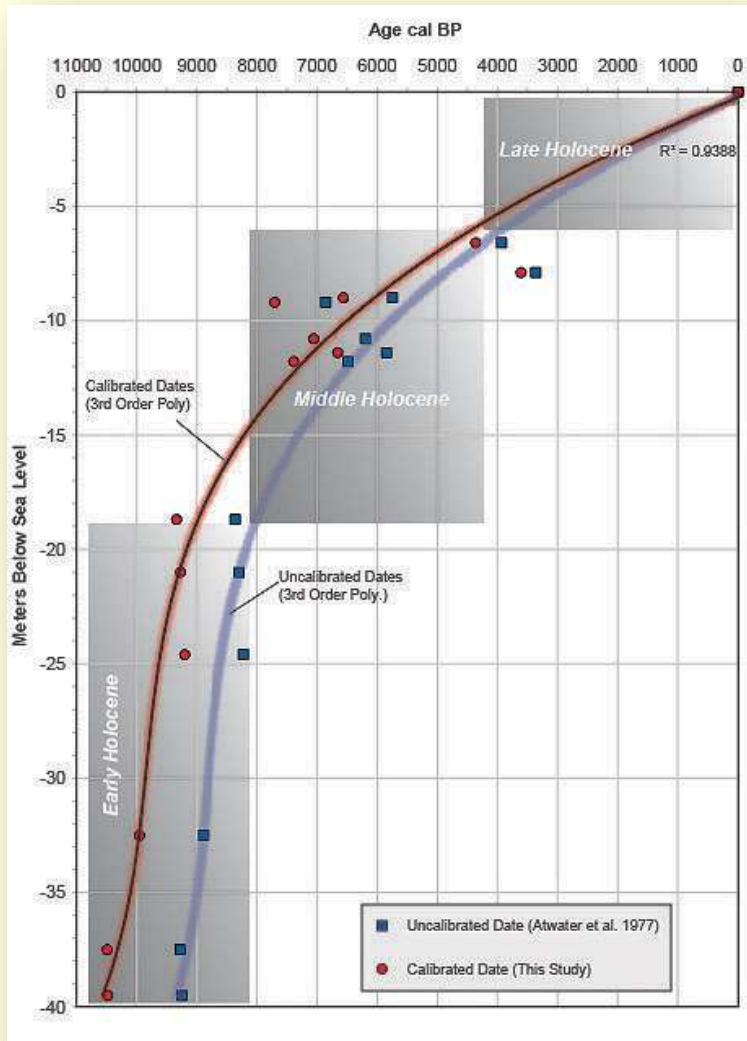


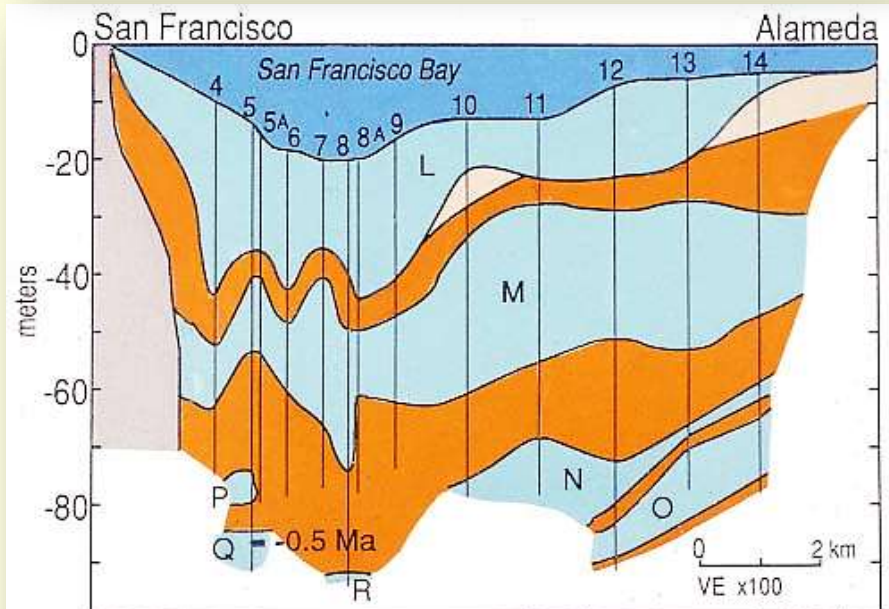
Figure 8. Holocene Evolution of the Sacramento-San Joaquin Delta Region.

Radiocarbon Dated Sea-Level Curve for San Francisco Bay: Atwater, Hedel, and Helley (1977)

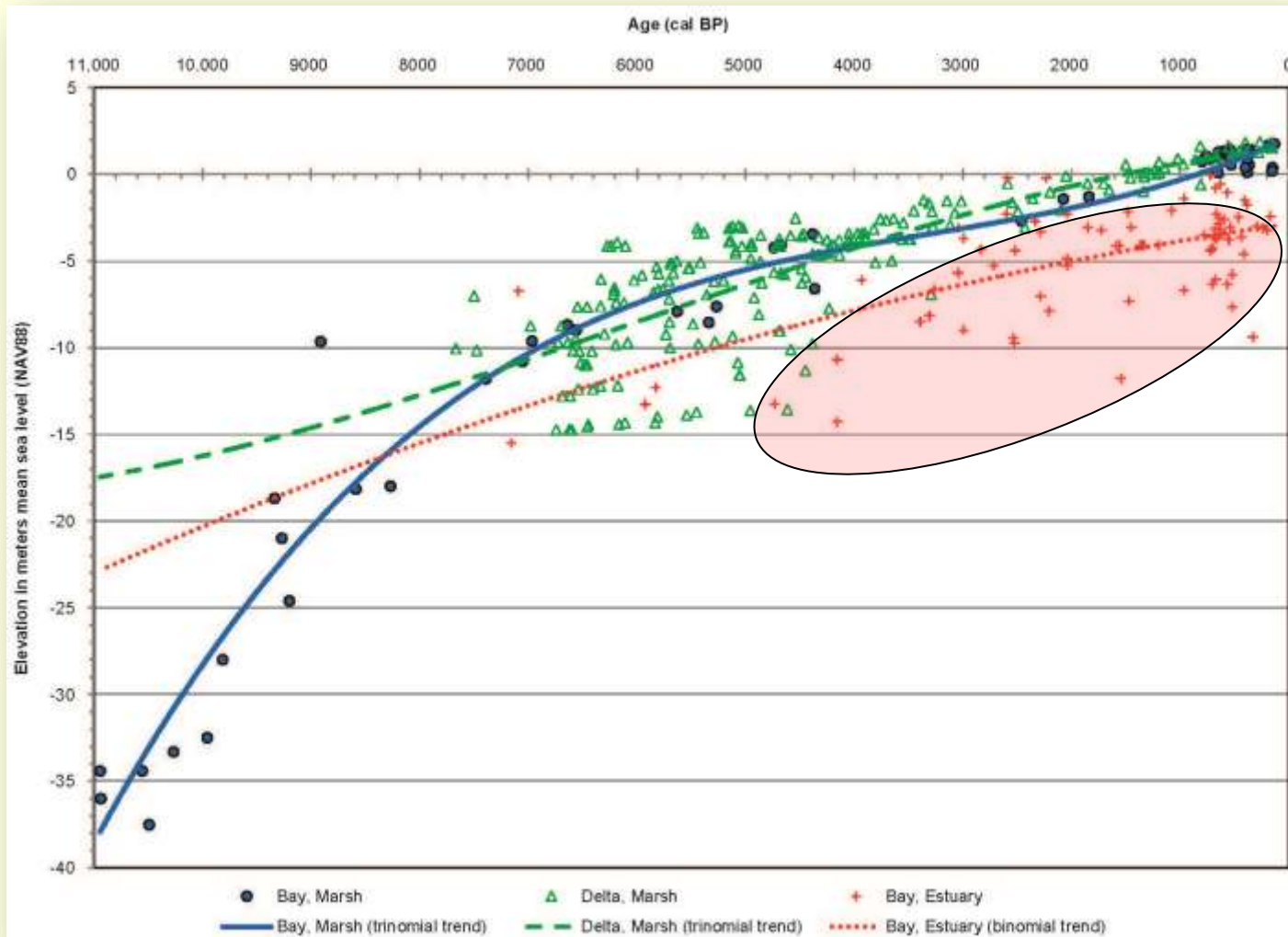


Late Quaternary Depositional History, Holocene Sea-Level Changes, and Vertical Crustal Movement, Southern San Francisco Bay, California

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Dates and Datasets used for New Sea-Level Curve

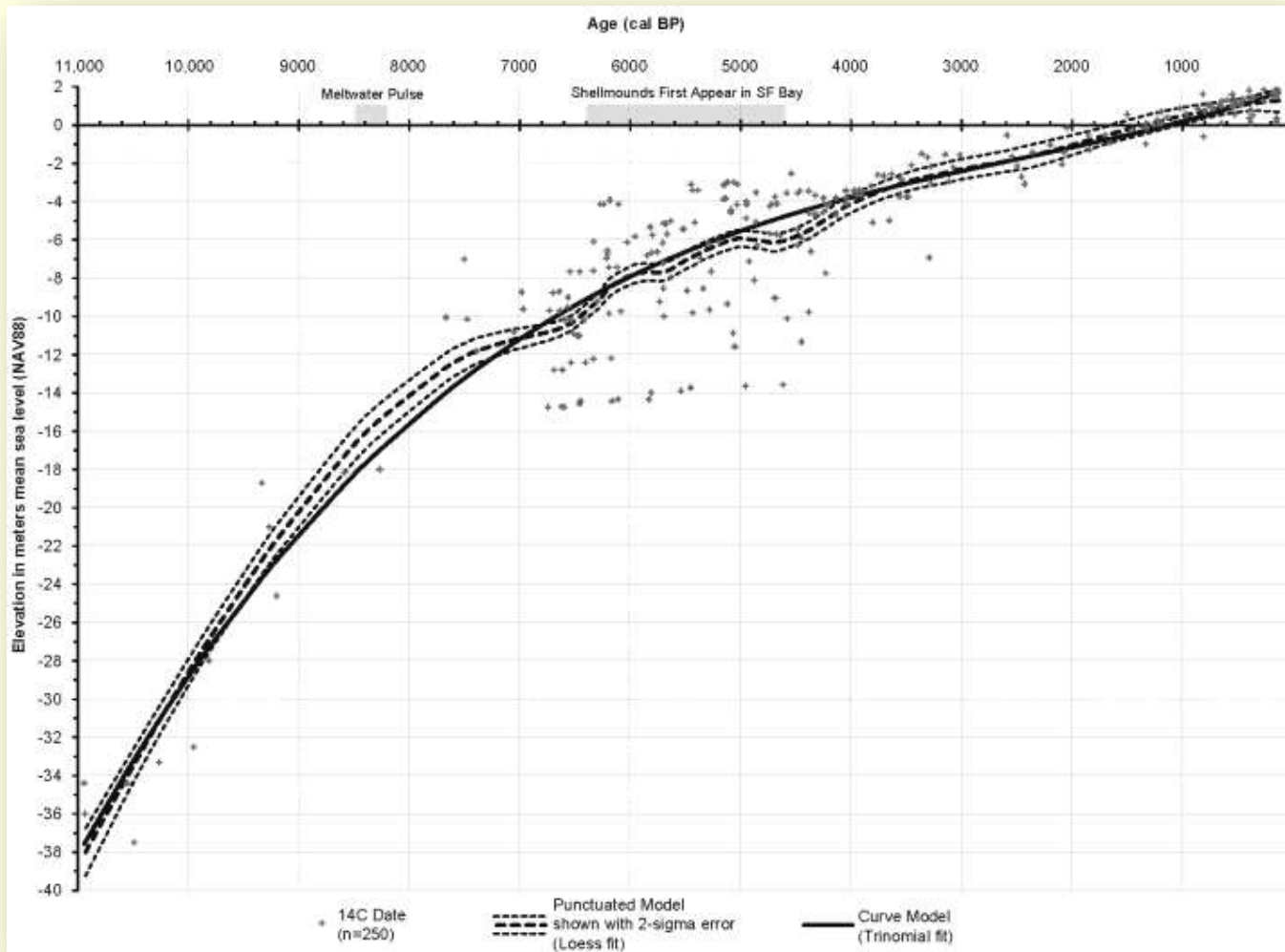


A total of 333 radiocarbon dates from the San Francisco Bay and Delta estuary system compiled and analyzed.

Dates from estuarine shells varied widely in age and elevation compared to non-shell samples, and therefore excluded.

New sea-level curve constructed using 250 dates from tidal and supra-tidal marsh deposits only.

Two Regression Models of Sea-Level: Polynomial Curve and Punctuated or “Loess Fit”



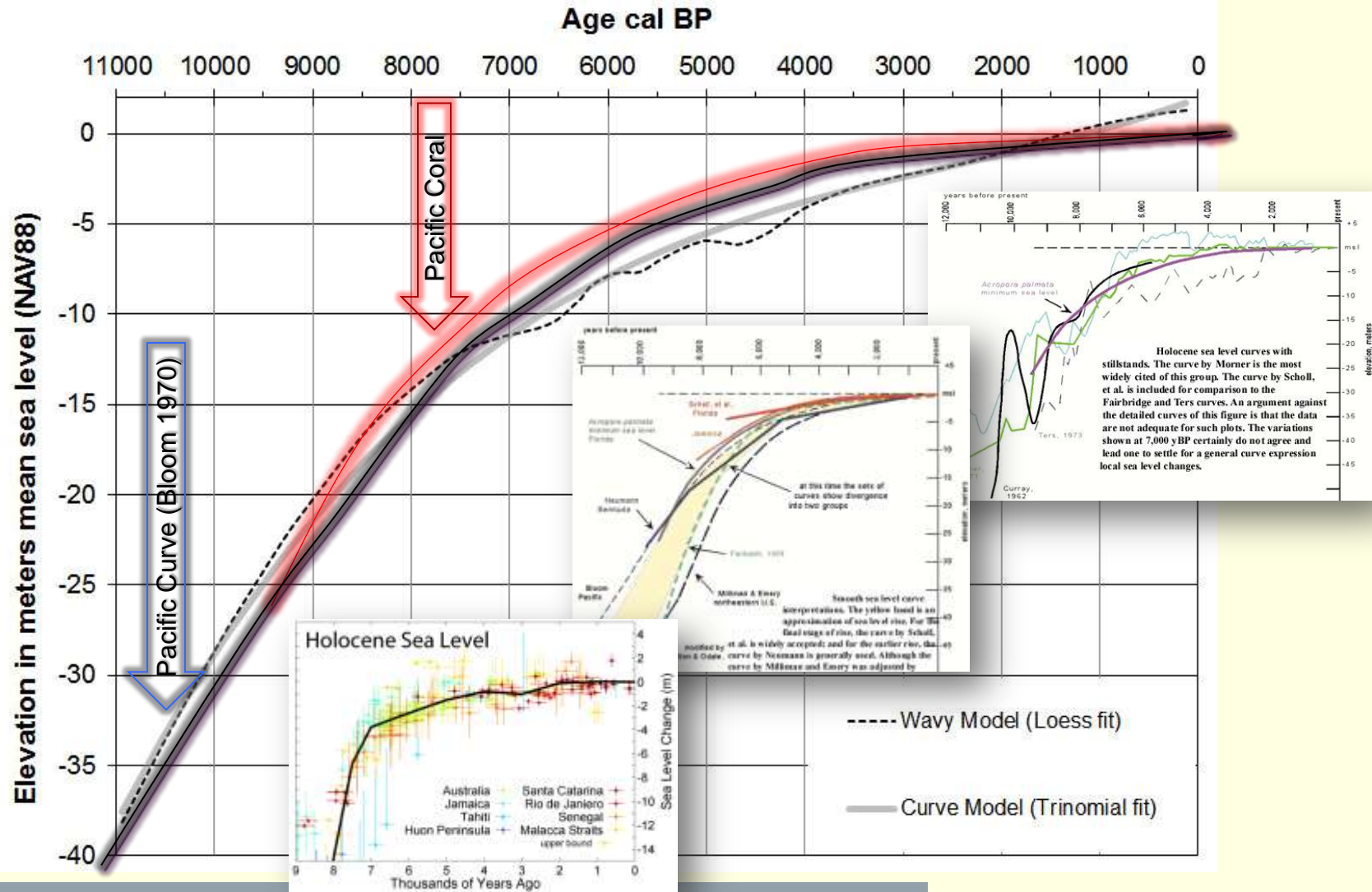
Both models are very similar when plotted against one another.

Punctuated shows three “flat” periods during the middle Holocene at:

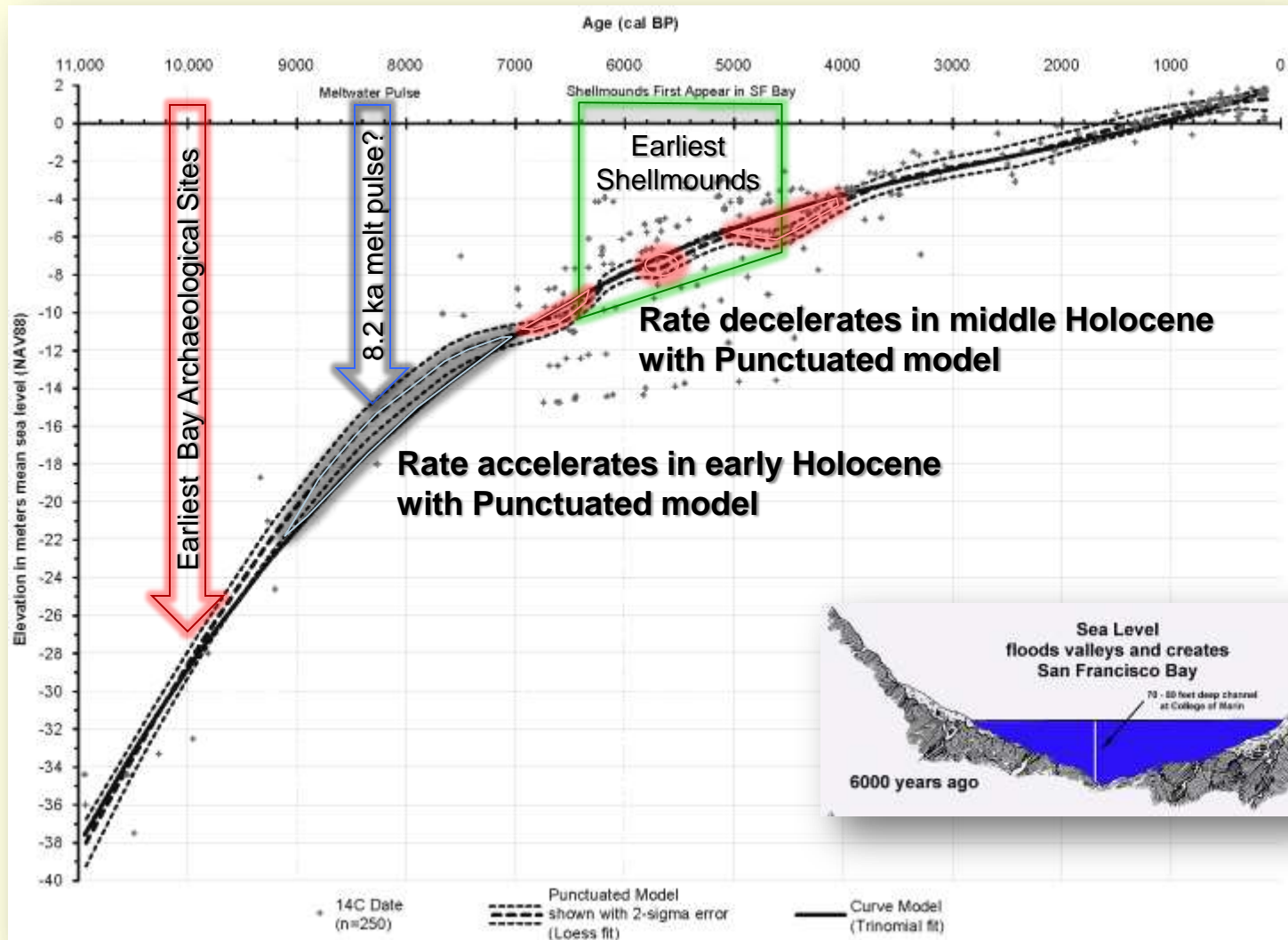
*7400 to 6600 cal BP,
6000 to 5600 cal BP,
5400 and 4600 cal BP.*

These may represent significant decreases in the rate of sea-level rise (i.e., “still stands” or “near still stands”) occurred during the Middle Holocene?

San Francisco Bay Curve Relative to Others



Archaeological Implications of the Models

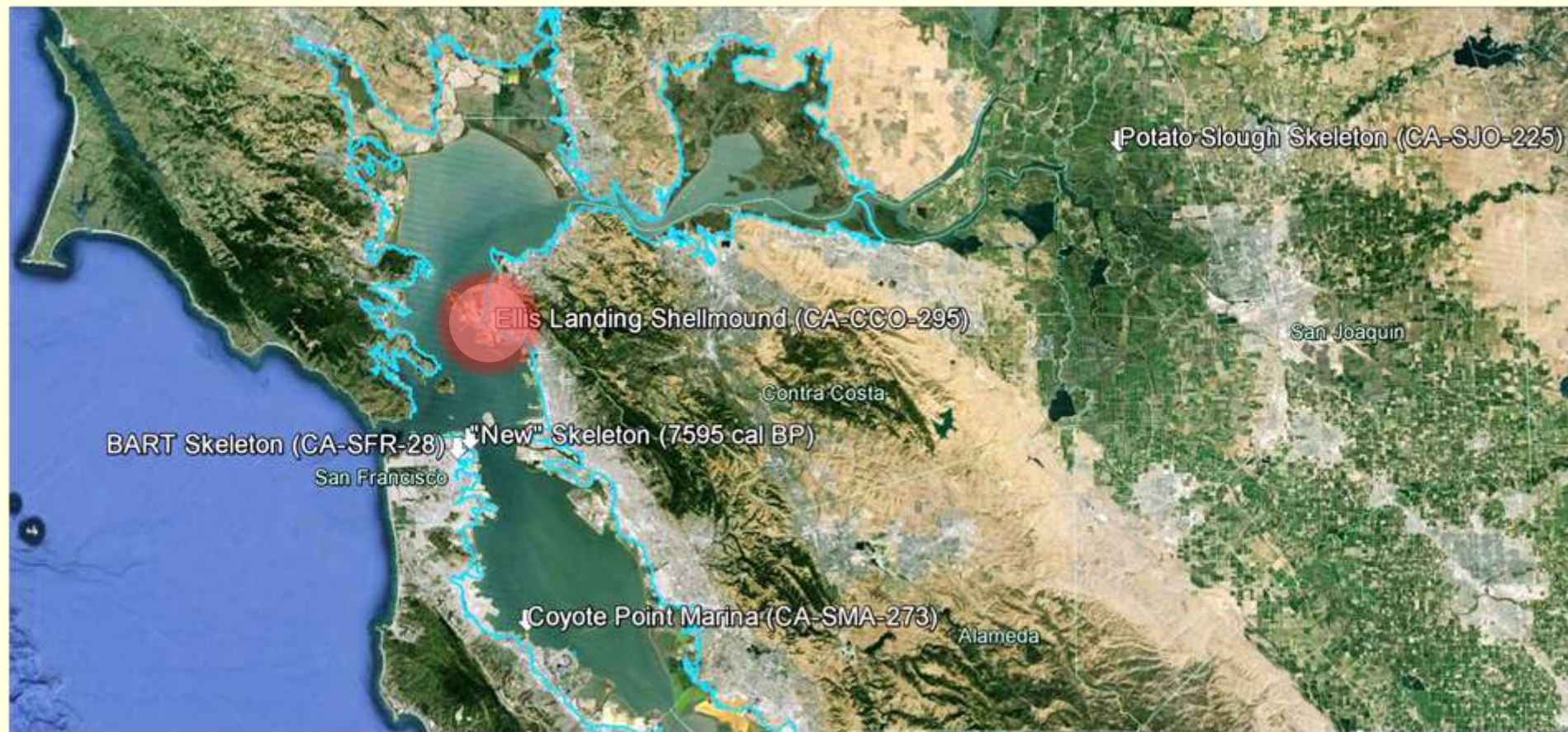


*As the land was drowned by the rising sea
the bay was formed where there was a valley*

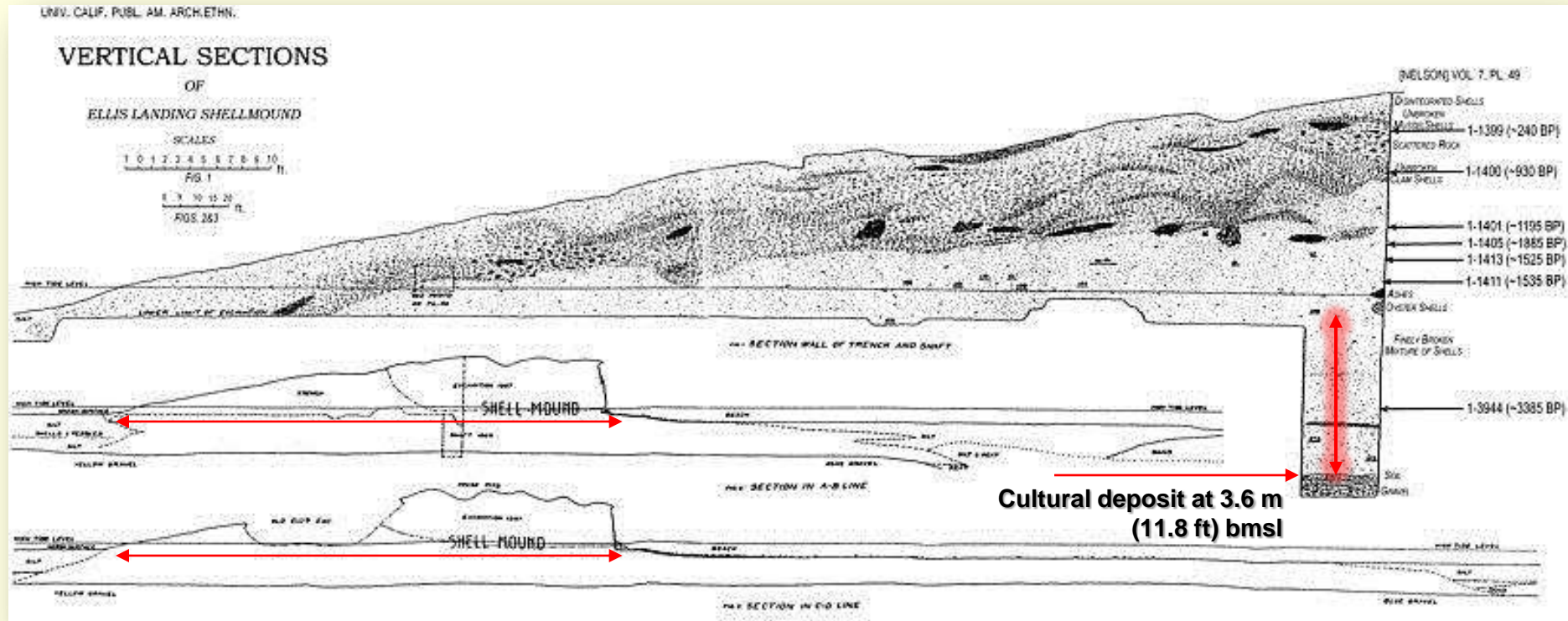


Beneath San Francisco Bay?

Submerged Archaeological Sites in San Francisco Bay Area



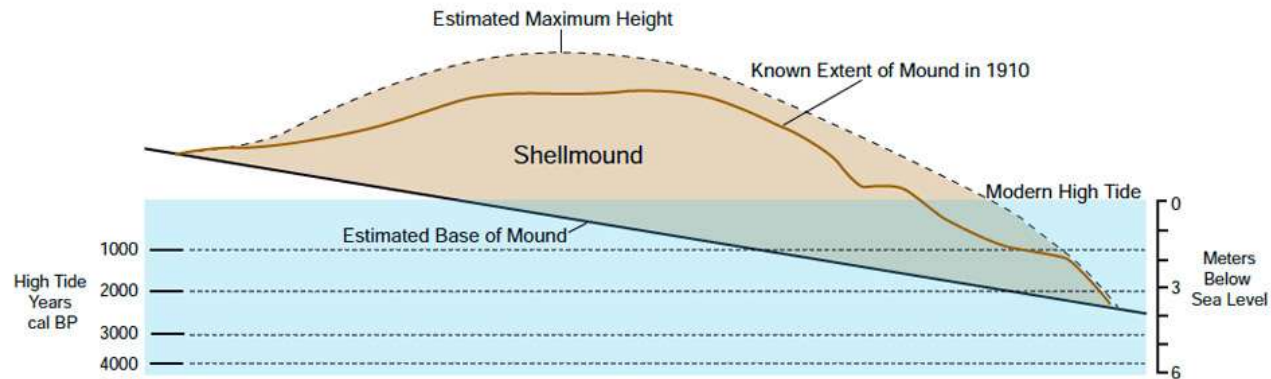
Ellis Landing Shellmound Stratigraphy (CA-CCO-295)



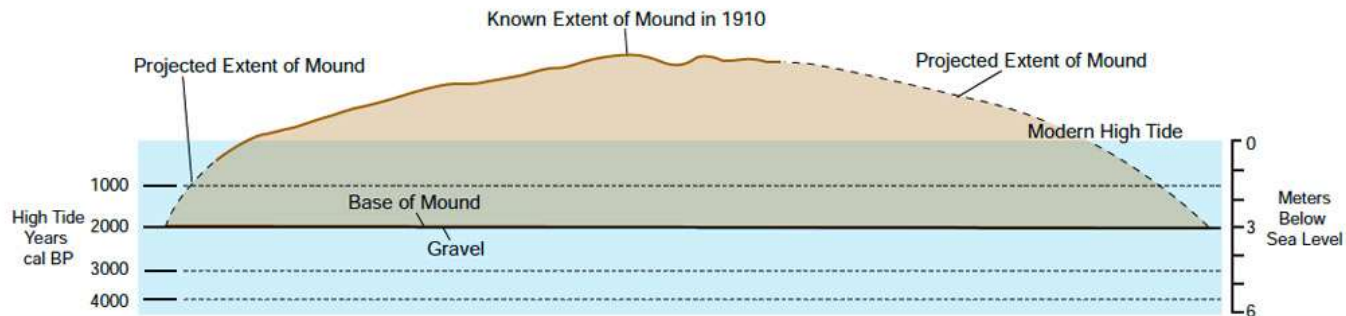
Nels Nelson (1910)

Base of Shellmounds in Bay Area

Submerged -3.0 to -4.0 meters below sea level



a. SFR-7, Bayshore/Crocker Mound.



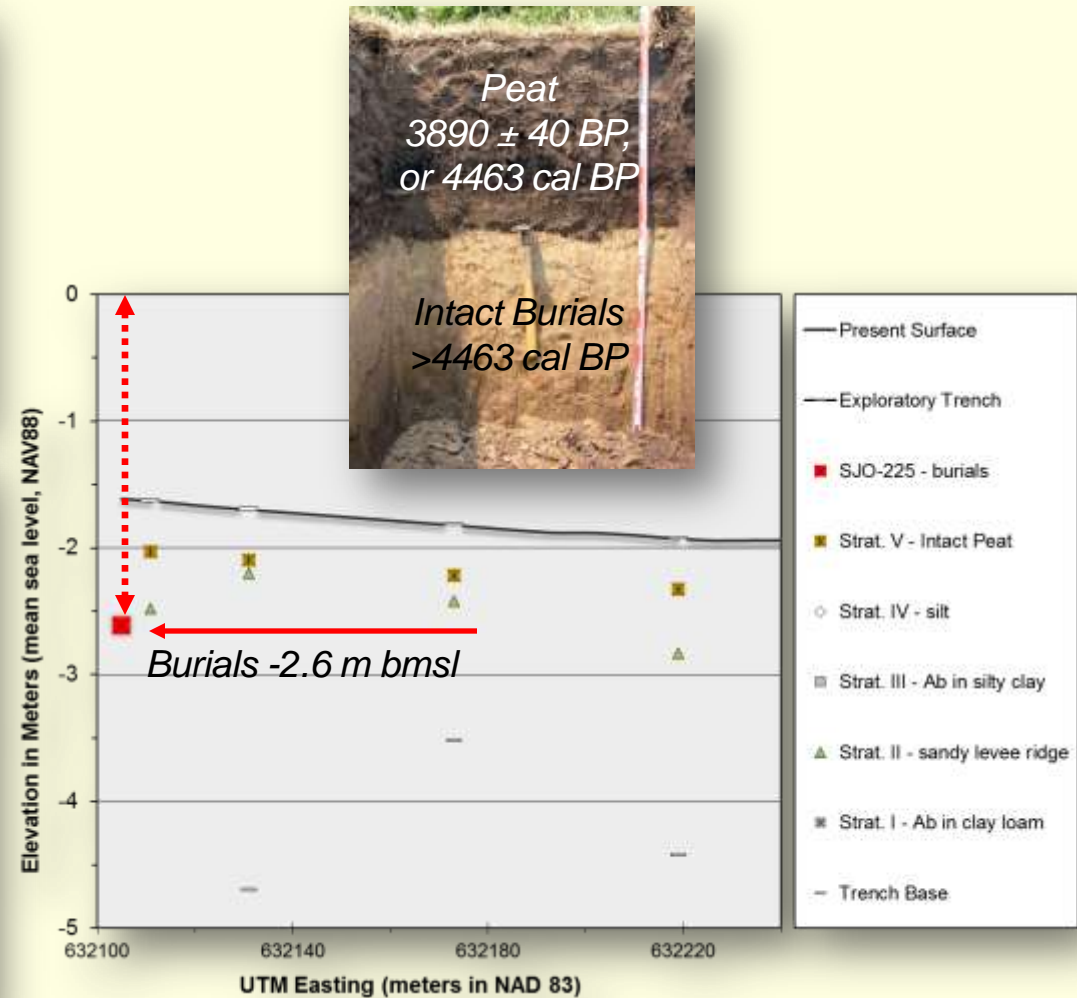
b. CCO-295, Ellis Landing Mound.

Potato Slough Burials (CA-SJO-225)

Sacramento-San Joaquin Delta



Potato Slough Burials (CA-SJO-225) Sacramento-San Joaquin Delta



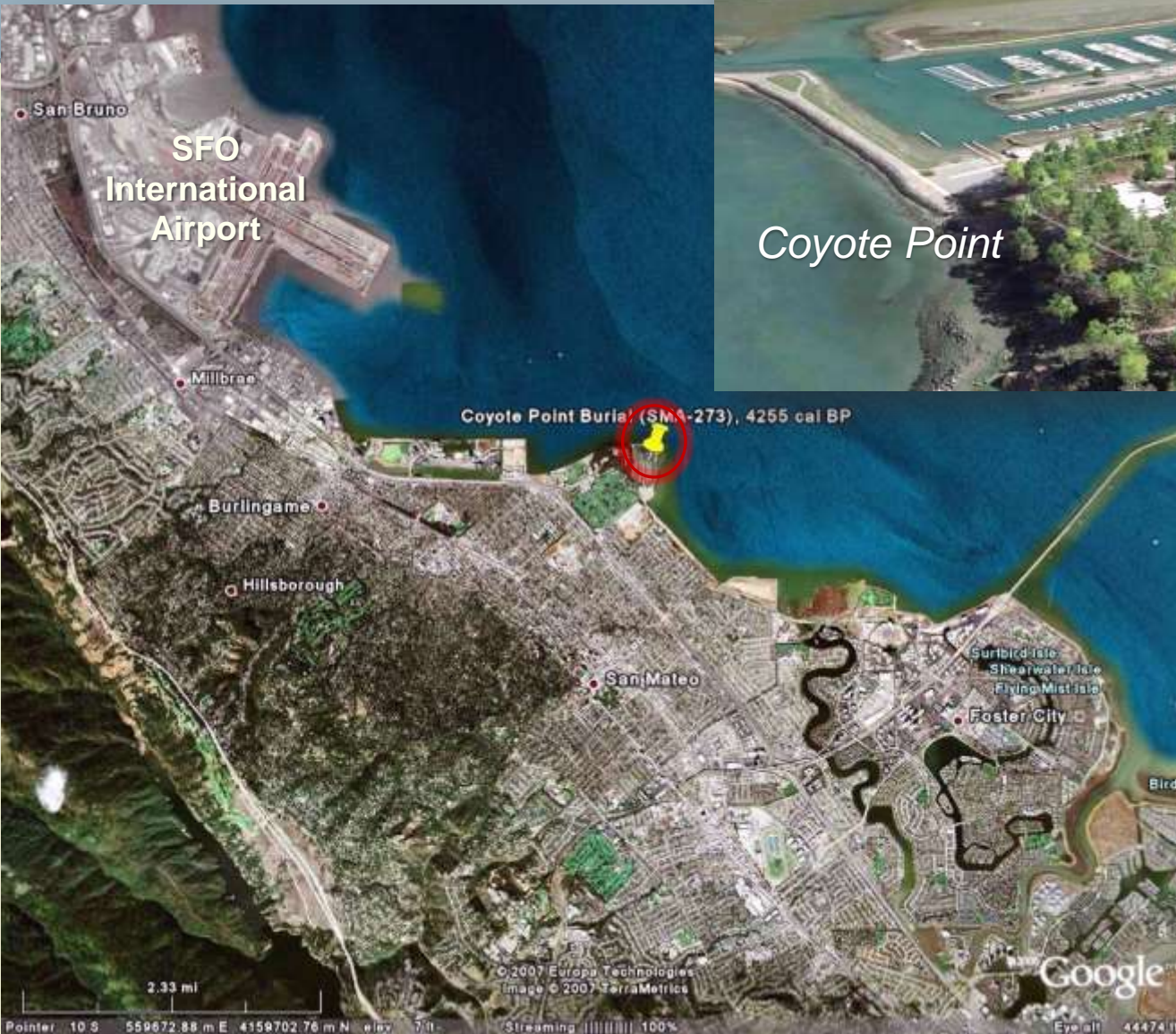
Coyote Point Skeleton (CA-SMA-273) Southern San Francisco Bay



Coyote Point (CA-SMA-273)



Coyote Point



*Intact human skeleton
at -3.65 meters (-12 ft.)
below sea level.*

Dated to 4255 cal BP

“BART” Skeleton (CA-SFR-28) at Bay Area Rapid Transit Civic Center Station



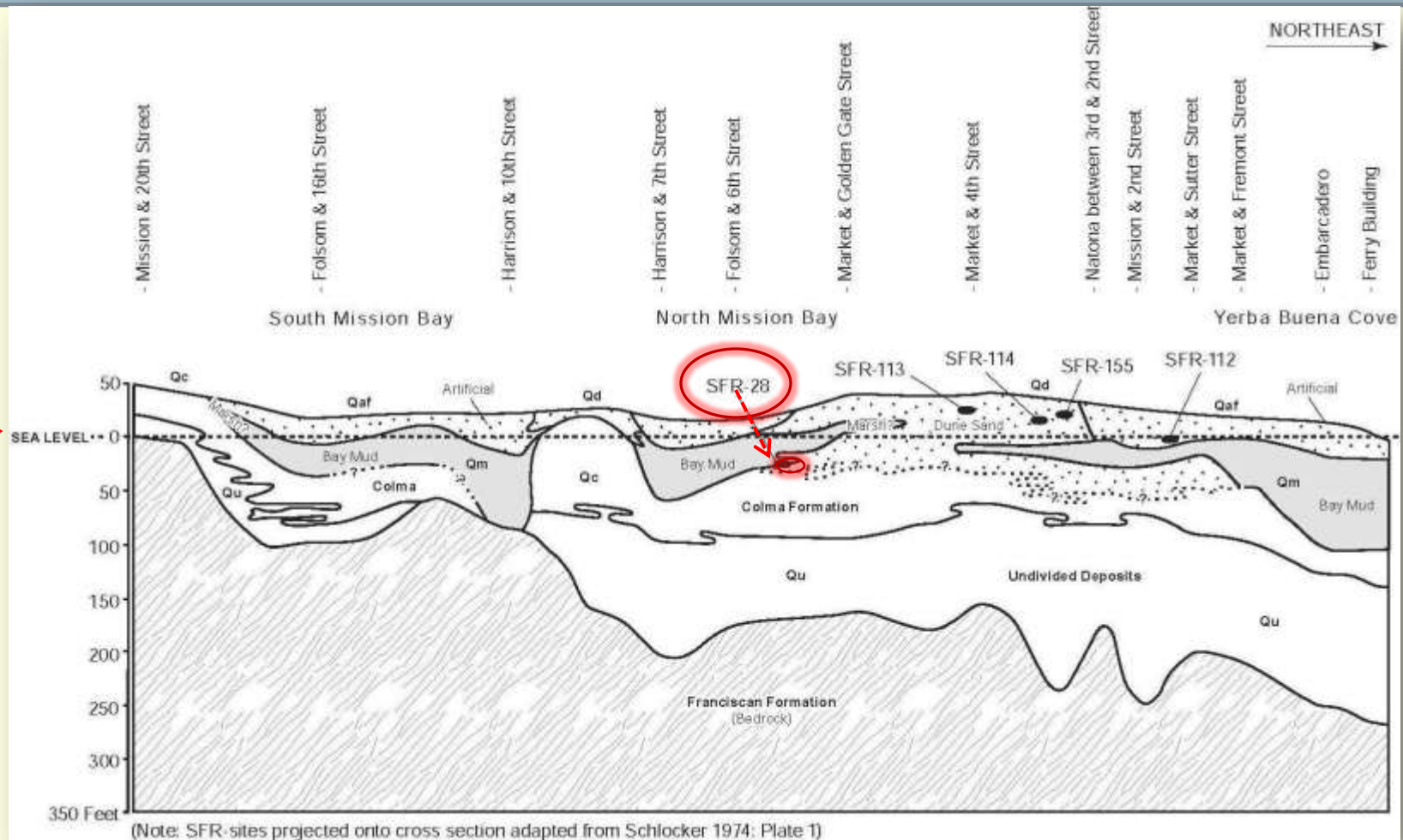
“BART” Skeleton (CA-SFR-28) at Bay Area Rapid Transit Civic Center Station



- Found while excavating the Market Street BART tunnel near Civic Center in 1969
- Isolated human skeleton discovered beneath 75 feet (22.86 meters) below surface
- Under 30 feet (9.1 m) of artificial fill and 45 feet (13.71 m) “Bay Mud”
- Called “BART Man” but was a female
- References: Henn and Schenk (1970) and Henn, Jackson, and Schlocker (1972)

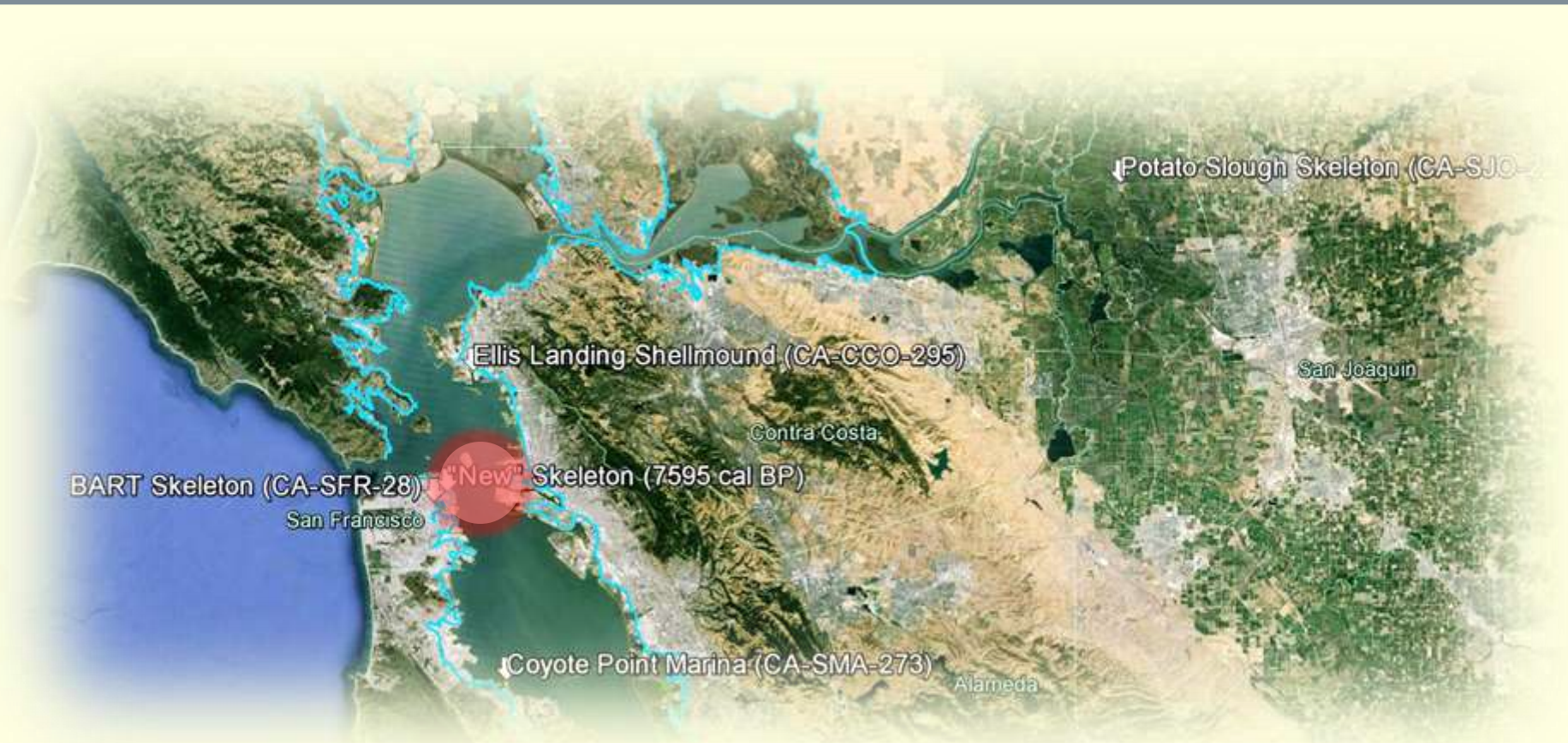
Skeleton ~7.0 meters (bmsl) dates to 5630 cal BP

“BART” Skeleton (CA-SFR-28) Submerged in former Arm of Mission Bay



Skeleton encased in Bay Mud near the base of the estuarine deposits

Yet Another Human Skeleton was Recently Discovered in Downtown San Francisco



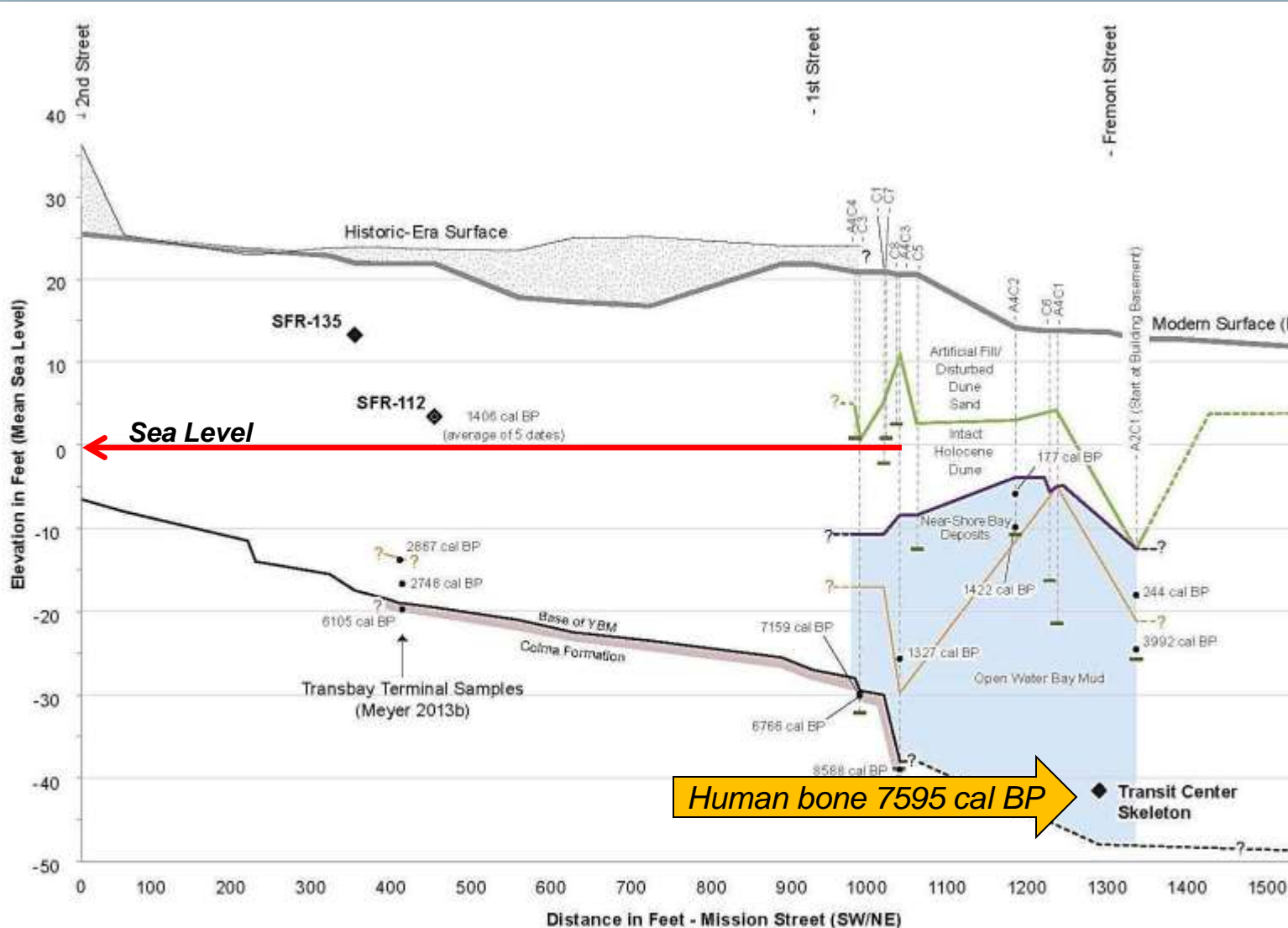
Fully-Articulated Skeleton Found Wrapped in a Woven Mat at Elevation of 12.8 meters (42 ft) bmsl, March 2014



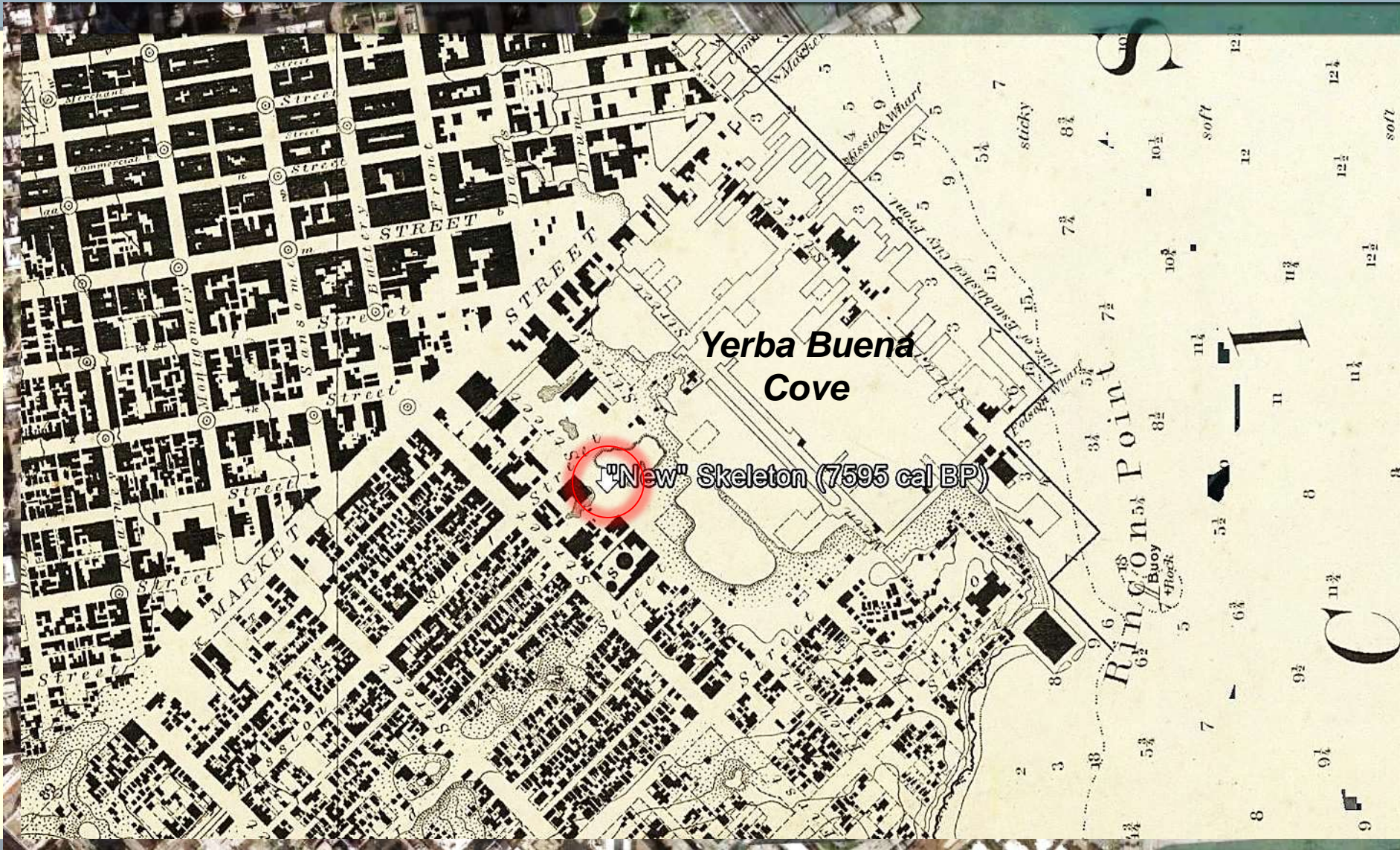
Transbay Terminal Tunnel Construction



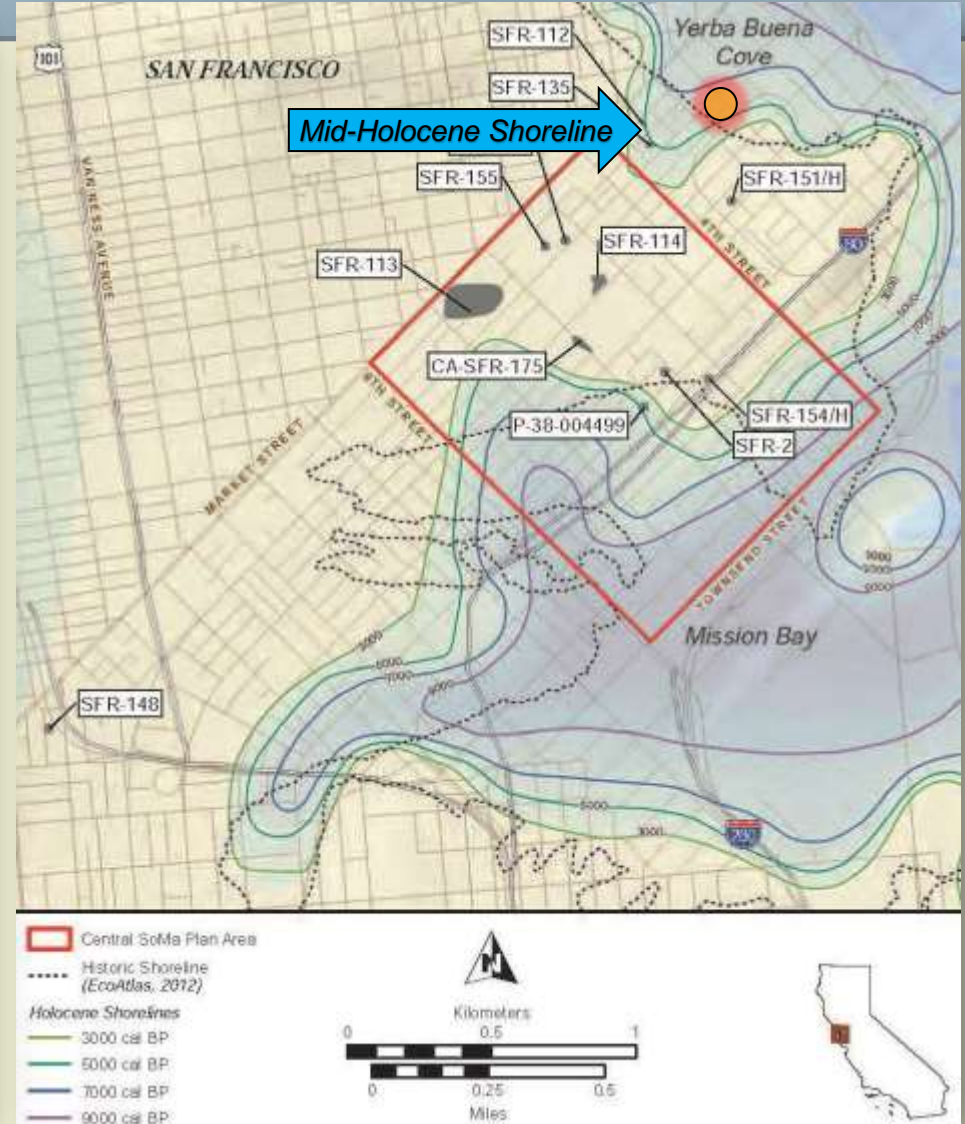
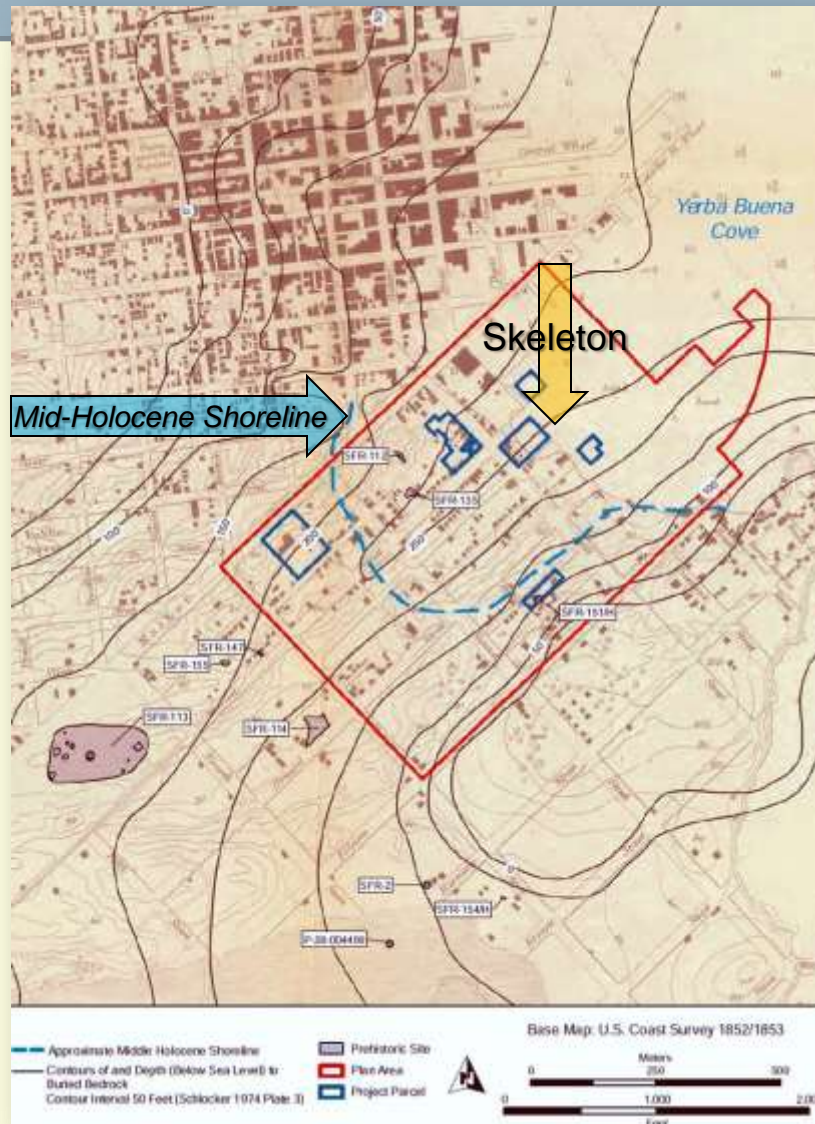
Skeleton Fully Encased in Estuarine Clay “Bay Mud”



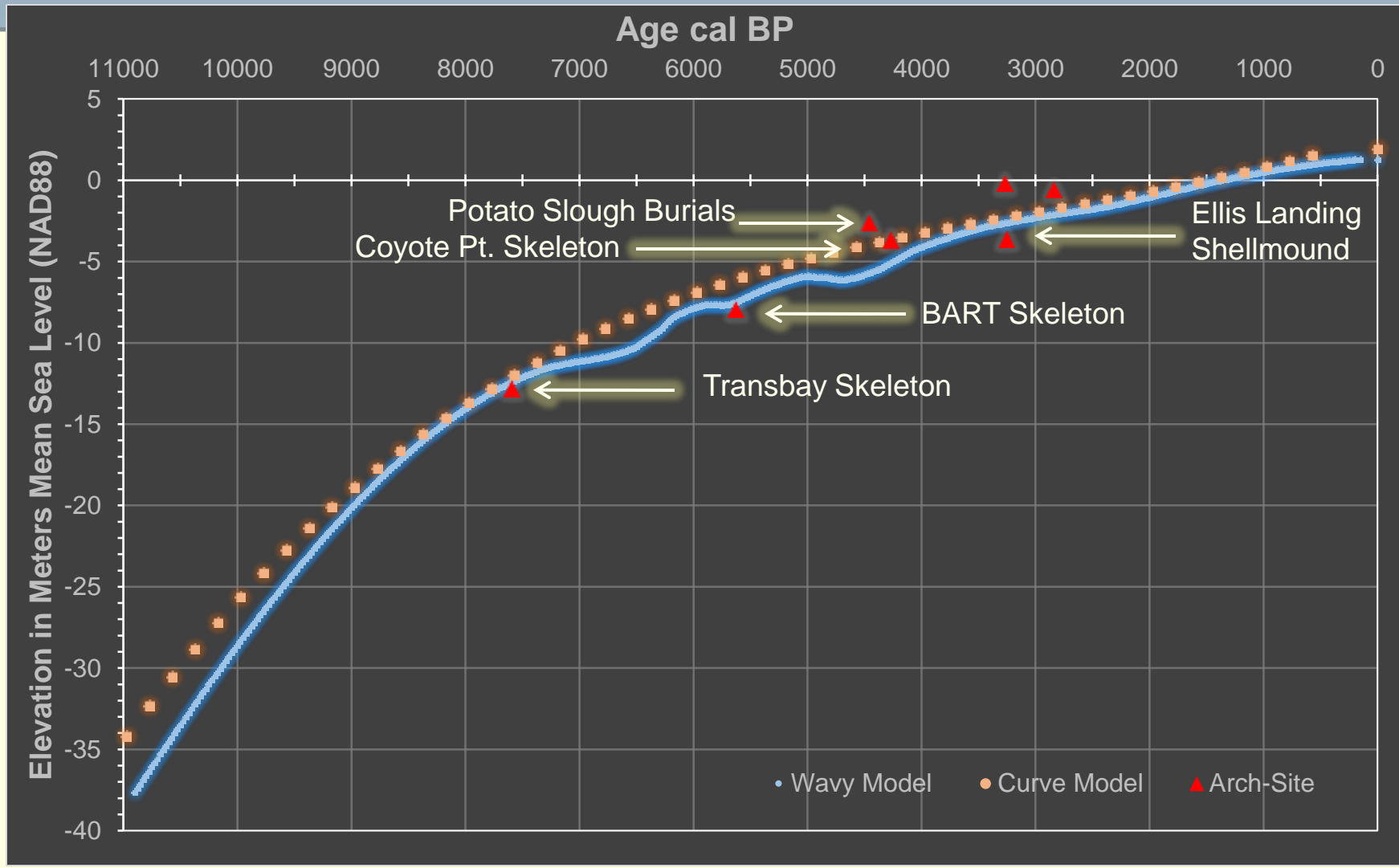
Skeleton was Submerged in Middle Holocene Estuary — Later Known as “Yerba Buena Cove”



The Age and Elevation of Transbay Skeleton are Nearly Identical to the Estimates Provided by the New Sea Level Curve



Age and Elevation of Transbay, BART, and Coyote Point Skeletons and Base of Ellis Landing Shellmound are in the 2-Sigma Error Range of Curve and Punctuated Models



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These discoveries underscore the need for accurate Holocene sea-level reconstructions to predict where buried or submerged prehistoric archaeological resources are likely located, and for evaluating long-term relationships between land, sea, and human occupation in the San Francisco Bay Area.



Thank You